



Science and Technology

**Providing Soldiers
the
Decisive Edge**

The U.S. Army Research Laboratory (ARL) is the Army's corporate laboratory. ARL is the leader in providing innovative solutions for the current and future Army; acknowledged for scientific, technical and analytical excellence, recognized as the bridge between the nation's science and technology community and the Army. Our mission is to "Provide the underpinning science, technology and analysis to enable full-spectrum operations."

This publication highlights some of our significant scientific and technical achievements throughout the decades by our workforce of over 2,000 dedicated military and civilian members working in seven directorates and offices. Over the years, they have dedicated themselves to providing the nation's Soldiers with the best they can provide.

ARL's research continuum stretches from early, long-term, basic research to evolving new technologies to supporting current operations. This publication will showcase some examples of the work ARL and its predecessor organizations have contributed and will provide a quick glance at research that is being conducted within ARL today that could produce unprecedented or enhanced capabilities for the Army of the future—10, 15 or even 20 years from now. Additionally, we will highlight some of ARL's current operations support that is possible because of the scientific and technological discoveries of our past.

The entire research and support staff of ARL fully understands that the laboratory's primary mission is to maintain technological superiority on the current and future battlefield. We understand the complexities of the environment in which we operate and the need to continue to field the most sophisticated and powerful Army in the world. This drives everything the laboratory does as it builds on the excellence of the research performed throughout the decades.

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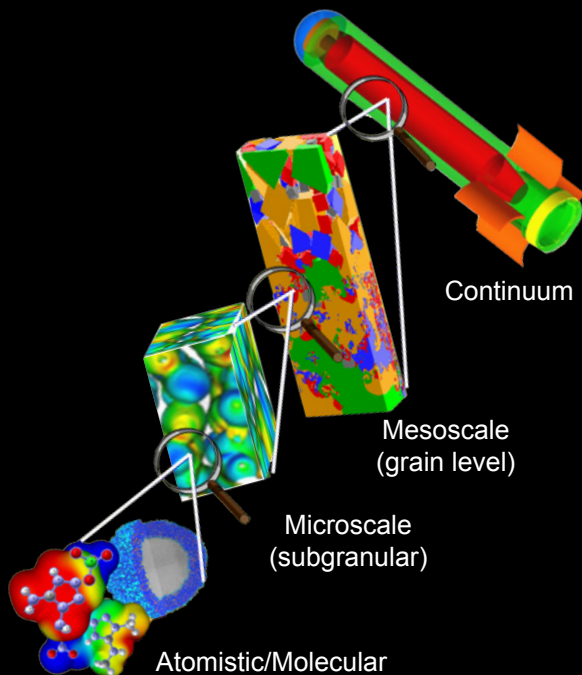


MANY MINDS, MANY CAPABILITIES, SINGLE FOCUS ON THE SOLDIER

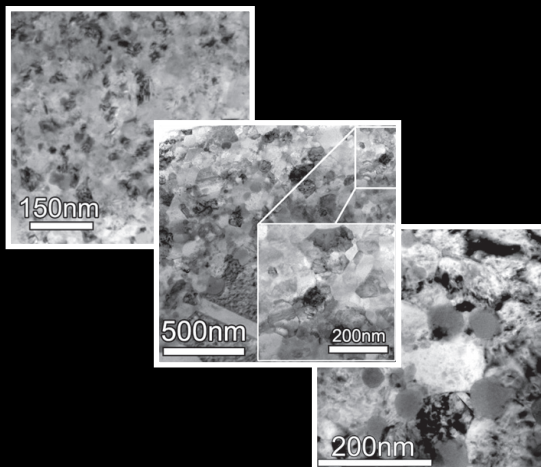
RESEARCH AND TECHNOLOGY FOR THE FUTURE

The science and technology discussed in this section are just some of the important work taking place throughout ARL today. The true benefit of this ongoing research will not be realized in the short-term, but will benefit the Soldier and Army of the future and will ensure their technological superiority on any battlefield.

Multiscale/Multidisciplinary Modeling of Materials



Nanocrystalline Materials Microstructural Control



MATERIALS IN EXTREME ENVIRONMENTS

Materials in extreme environments provide cross-cutting material technologies to enable the next generation of protection, lethality, electronics and power concepts that reduce weight while enhancing capabilities.

What we do: Design, develop and synthesize structural and electronic materials with properties and capabilities that were previously unforeseeable/unattainable.

Why: To provide the U.S. Army with a new generation of material and material systems to enhance the performance, lethality and survivability of Soldier and ground combat systems.

How:

Multi disciplinary/Multi-scale Modeling and Simulation

- Use the power of petaflop computing: Physics-based predictive capability
- Advance Multiscale Material Modeling and Simulation from the atomic to the continuum

Enable a new generation of experimental physics and material characterization

- Interrogate material response dynamically in high stress and high rate environments
- Interrogate material response from the atomic to the continuum
- Interrogate material response chemically, electro-dynamically and structurally

Processing-structure-property relationships

- Define material properties and characteristics from the atomic scale to the continuum
- Processing to optimize material characteristics and properties
- Processing to create multifunctional materials

Materials by Design

- Demonstrate the capability to design advanced materials for U.S. Army applications
- Advanced materials for multifunctional armor, vehicle structures and precision weapons
- Novel materials for communications, power and energy, sensors and battlefield effects

RESEARCH AND TECHNOLOGY FOR THE FUTURE

DISRUPTIVE ENERGETICS

One of ARL's strategic initiatives that will revolutionize energetic science.

What we do: Develop enabling energetic technologies to bridge the technology gap that exists between conventional energetics and nuclear events and apply the right lethality at any place and any time without putting the Warfighter in harm's way.

Why: Disruptive energetics technology will enable smaller, lighter munitions; provide scalable and multipurpose energetics; and strengthen Army operations by providing green insensitive energetics.

How:

Innovative Experimental Capability

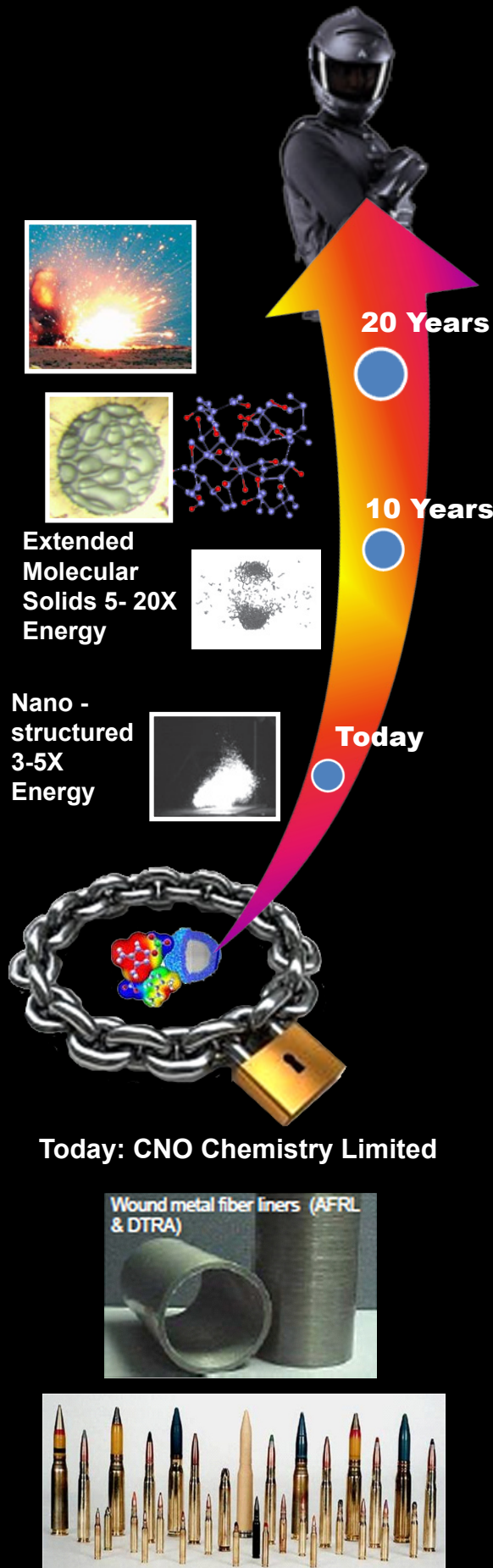
- Study material behavior under thermomechanical extremes
- Laser studies of nanoenergetics
- Thermochemical and energetic performance testing
- Novel scale-up approaches from nanograms to micrograms to kilograms

Revolutionary Computational Capability

- Development of robust quantum mechanical codes to provide insight into the molecular response of material to thermomechanical extremes
- Development of multiscale capability to simulate energetic material response to insults by capturing the effects of microstructure
- Develop an understanding of how material properties can be controlled to reach basic limits of energetic material performance



Same performance at 1/100th of weight



RESEARCH AND TECHNOLOGY FOR THE FUTURE

NETWORK SCIENCE

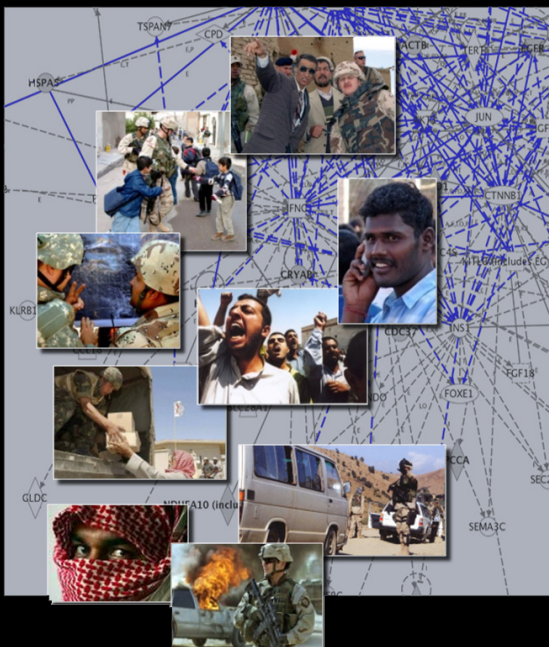
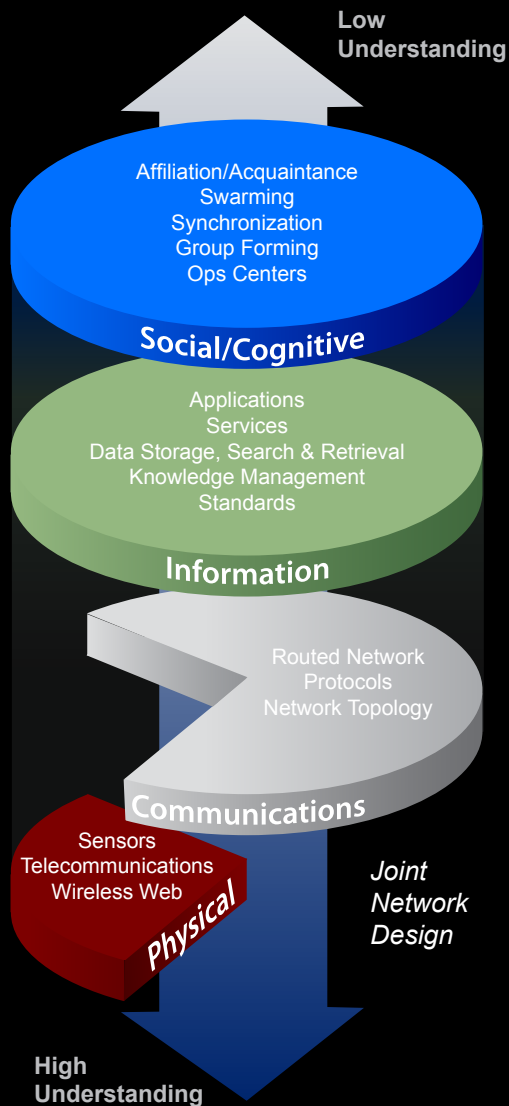
Network science studies fundamental laws of evolution and behaviors of “living” networks, treating them as holistic organisms. Networks of all kinds—biological, social, computer—are in a unique class of creatures, which live their own mysterious lives: evolving, changing, and behaving in little-understood ways.

Network science enables revolutionary advances in the ability to model, design, analyze, predict and control the joint behavior of secure (tactical) communications, sensing and Command and Control (decision-making) networks. Network science objectives include development of networks and applications that adapt based on Warfighters’ information needs; analytical models and protocols to enable performance optimization of composite (social, information, communications) networks; trust management approaches to secure and enhance networked distributed decision making; emulation techniques to investigate complex mobile networks; channel characterization and modem development to use less congested regions of spectrum; enhanced performance for networked sensor radios; and cyber threat analysis and intrusion detection effective against advanced persistent threats.

What we do:

We research foundational science to:

- Learn how to monitor, measure and assess the performance and behavior of the social, information, and communication (SIC) networks
- Understand and quantify the dependencies and causalities in the complex networks
- Predict the networks’ evolution and upcoming risks (e.g., loss of information quality or trust)
- Influence, adapt, and optimize the behaviors of networks to support a mission’s success



RESEARCH AND TECHNOLOGY FOR THE FUTURE

Why:

To understand interactions between information, communications and social/cognitive networks which enables improved decisions on and off the battlefield. Tools to anticipate and mitigate the impact of networks on distributed decision making.

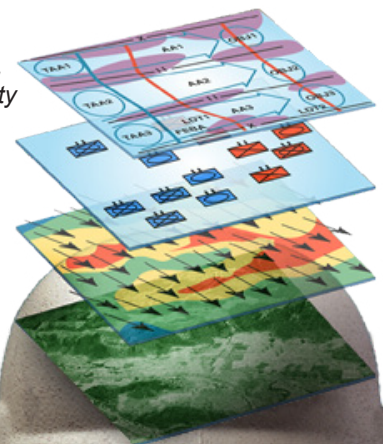
How:

By conducting research in the following areas:

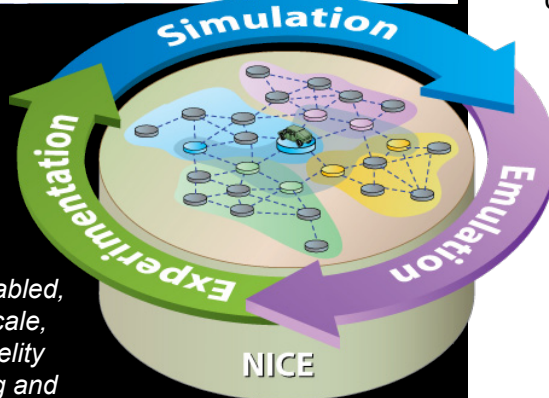
- Network Theory: Consensus between complex networks and dynamics of complex networks
- Emulation and Simulation: the Wireless Emulation Laboratory (WEL) and Cognitive Assessment, Simulation, and Engineering Laboratory (CASEL) to develop reliable, scalable trust management, dynamic network optimization, network of robotic operators and cognitive networks.

ARL is applying the following innovation: Explicit use of information quality metrics to increase the operational information capacity of networks; composite trust models that capture interactions between communication, information, social and cognitive aspects of networks; UV networked communications channel modeling incorporating multiple scattering of photons; low energy long-lasting mesh network sensor radios that support a wide range of data rates; use of automated network characterization techniques to inform cyber defense tools; generalized threat analysis framework that allows rapid insertion of specialized plugins; and architecture to support cyber analysts in tactical mobile environments.

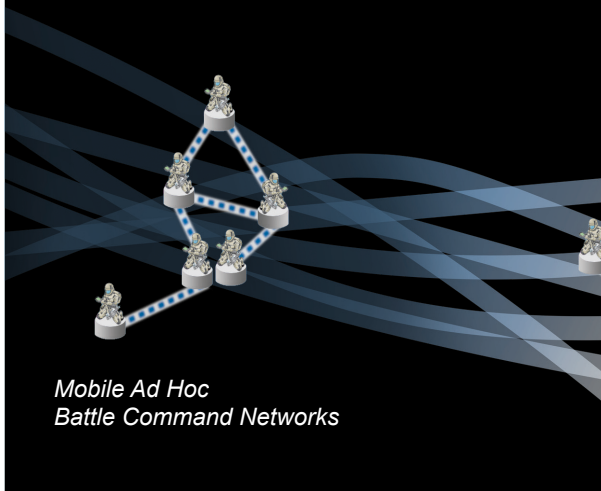
Adaptable networks maximizing information delivered to the Warfighter, based on information quality and decision context.



Information Dominance



HPC-enabled, Large Scale, High Fidelity Modeling and Simulation



Mobile Ad Hoc Battle Command Networks

RESEARCH AND TECHNOLOGY FOR THE FUTURE

HIERARCHICAL COMPUTING

Lead the way to create direct solutions for the Warfighter using asymmetric core computing to put the power of supercomputing in the hands of the Soldier for better control of battlespace applications. Find novel uses for this technology. Our approach is affordable since it is based on off-the-shelf commodity resources. Allow for rapid technology insertion of new research advances without lengthy dedicated hardware design and acquisition.

What we do: Perform the basic and applied research necessary to address a way to tap into an ever-growing set of computers. This is accomplished by addressing large-scale supercomputers at the top in terms of computing power to an ever-growing set of hand-held devices at the bottom. This will allow us to harness the power of the vast array of hierarchical computing assets moving into the Army battlespace.

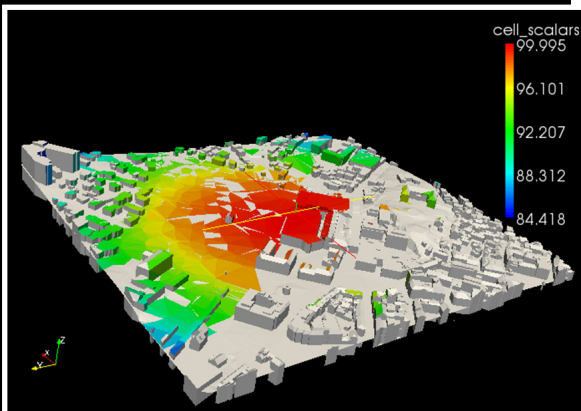
Why: Our research in hierarchical computing allows for rapid technology insertion of new laboratory advances without lengthy dedicated hardware design.

How:

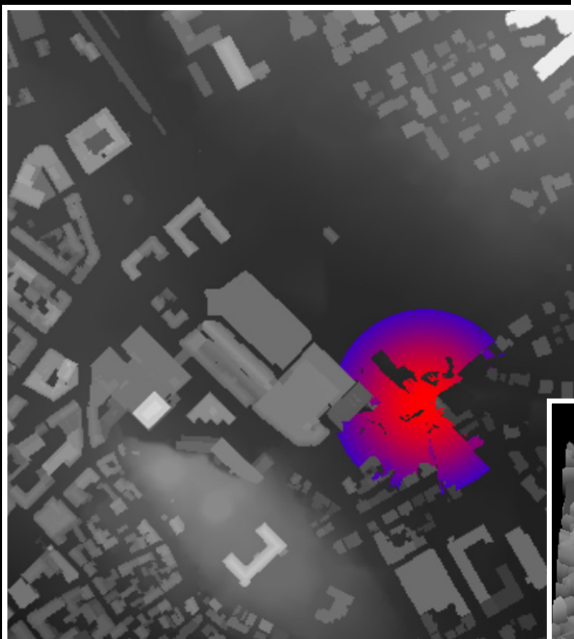
- Engage in basic computer science algorithm design and analysis research to develop software that will run as fast as possible on any computer processor and is smart enough to intelligently migrate to the right processor.
- Expand investigations of hardware into multicore central processing units (CPUs) and massively parallel computing found in graphics processing units (GPUs), originally designed to support the computer gaming industry, for Army applications.



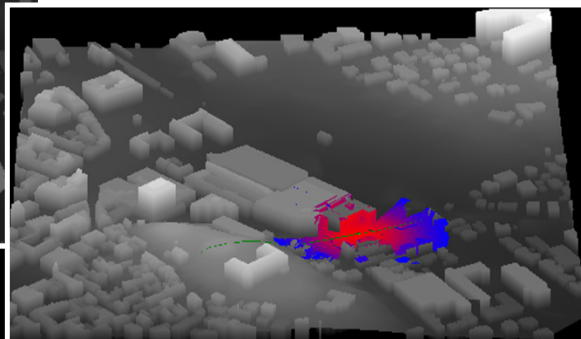
Deployable GPU System



Ballistic Threat Identification



**Way-point Planning
Minimized Threats**



RESEARCH AND TECHNOLOGY FOR THE FUTURE

HETEROGENEOUS ELECTRONICS

Researches novel and potentially disruptive electronics concepts that encompass physics, chemistry, materials science and device concept engineering on an appropriate timescale based on the maturity of the field. Research in this area is evaluating a whole new class of materials such as carbon nanotubes and graphene. These materials could revolutionize electronics and how we use them to support the Soldier of the future. Below is an example of the research taking place with graphene.

What we do: Investigate graphene electronic materials to create a new class of multifunctional electronic devices and sensors that are transparent, printable, stretchable and ultra compact, and require low power.

Why: Potential enhancement for future Soldiers' communications capabilities and survivability in the areas of imaging, navigation, power and sensor components.

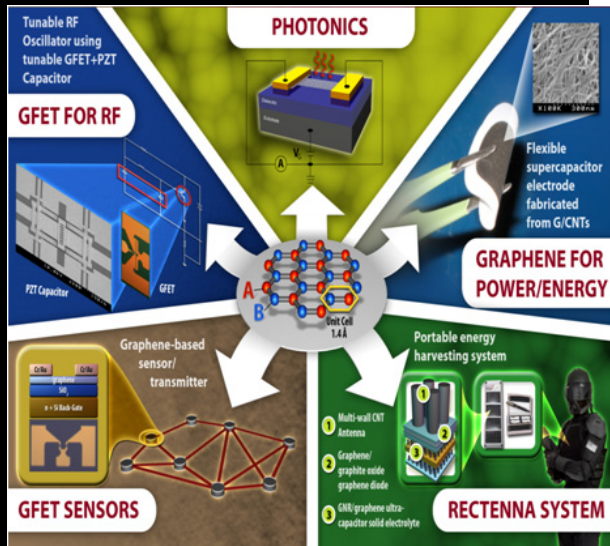
Graphene has exceptional properties:

Strength	Atomic layer thickness
Conductivity	High surface area
Flexibility	Chemically inert
Transparency	Thermal conductivity

How:

Material growth and properties including:

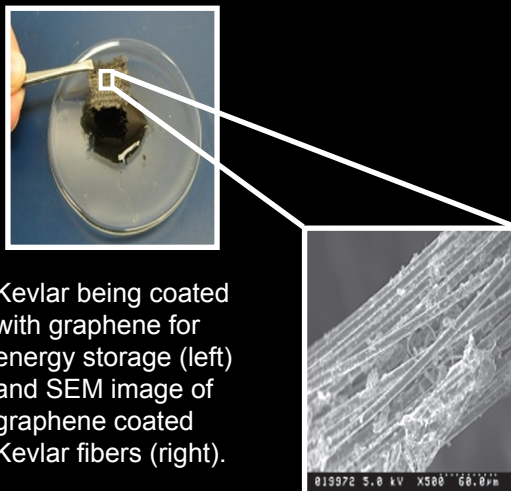
- Develop device modeling simulation and validation techniques.
- Design and fabricate novel device concepts.
- Establish infrastructure for testing and evaluation of graphene-based electronics.



Dismounted Soldier Power

Examples Capability:

Flexible super-capacitors with high energy and power density.



Kevlar being coated with graphene for energy storage (left) and SEM image of graphene coated Kevlar fibers (right).

RESEARCH AND TECHNOLOGY FOR THE FUTURE

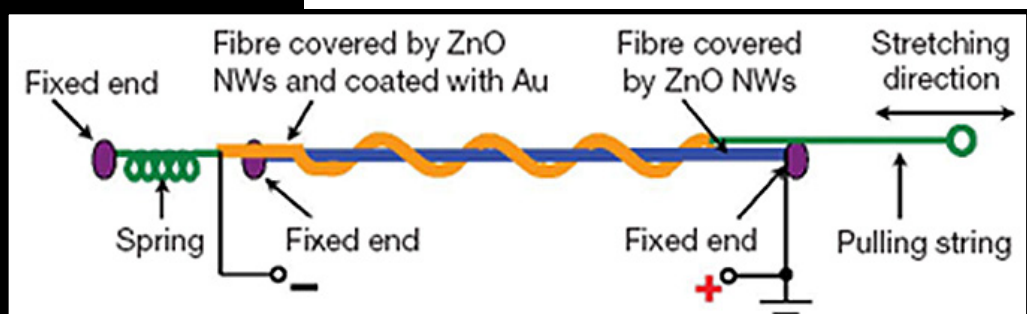
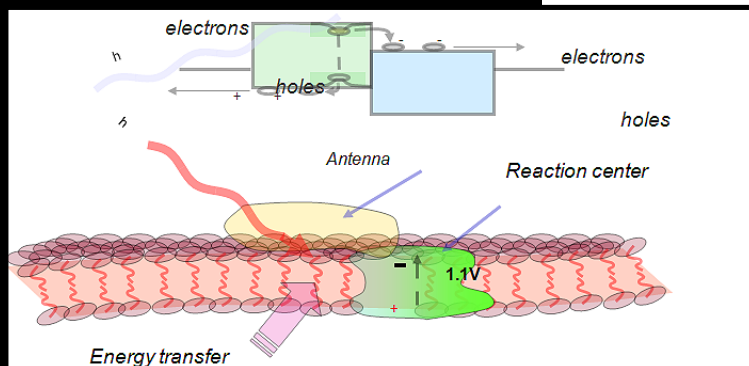
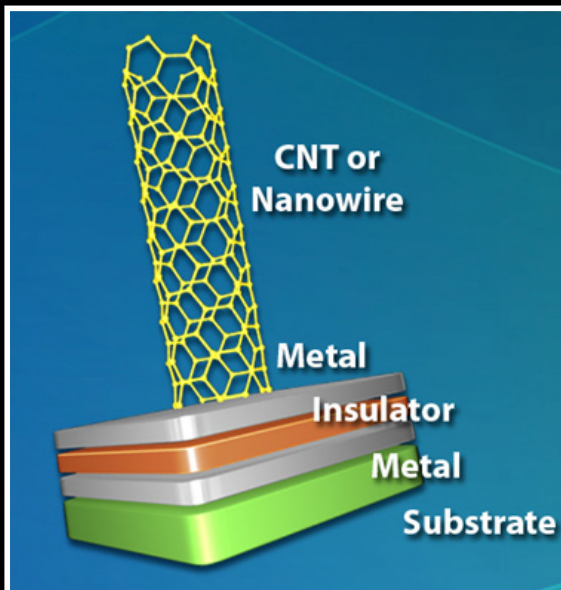
EXTREME ENERGY SCIENCE

Provides dense electronic component technologies from nano-to macroscales that provide power and energy to enhance the mobility, survivability and lethality of the current and Future Force while reducing logistic burden to the Warfighter. One focus area in extreme energy science is energy harvesting and scavenging.

What we do: Perform basic and applied research necessary to extract energy from Warfighter activities or the environment, which can be stored and converted to power in energy starved/high demand situations. Research areas include photovoltaics, thermoelectrics and piezoelectrics.

Why: Today, the individual Soldier must carry all his/her energy for the mission on his/her back or must be supported by an extensive equipment/logistics train. Our research will permit the Soldier to extract energy from the surrounding environment, which lessens the logistical burden.

How: Sense and harvest energy in the environment due to indigenous radiation or intentional power transfer. Extract solar energy using photovoltaics, thermal energy using thermoelectrics, vibrational energy with piezoelectrics, and scavenge energy from motion or biological phenomena.



RESEARCH AND TECHNOLOGY FOR THE FUTURE

AUTONOMOUS SYSTEMS TECHNOLOGY

Enables the dismounted Soldier, fighting in urban terrain, to command a suite of small, autonomous unmanned systems (air, ground and hybrid vehicles) in order to gain intelligence on the contents of urban structures.

What we do: Advance the fundamental science and technology along key cross-cutting thrust areas relevant to small-scale platforms: mobility, control and energetics; communication, navigation and coordination; and sensing, perception and processing.

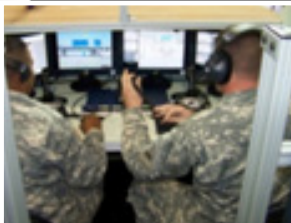
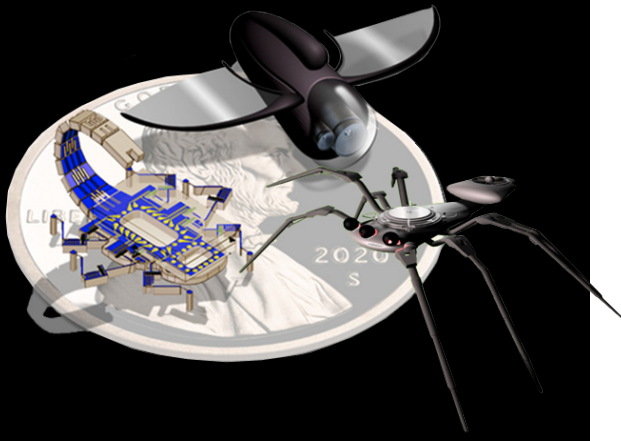
Why: Provide the underpinning science to enable palm-sized and smaller autonomous robotic platforms, both aerial and ground, that will extend the Warfighter's situational awareness in complex terrain and confined spaces like caves or urban environments.

How: Established a Collaborative Technology Alliance between the government, industry and academia for the following areas:

- Sensing, perception and processing for size and resource constrained systems
- Communication, navigation and coordination for size and resource constrained systems
- Mobility, control and energetics for size and resource constrained systems

Enhanced Capability Achieved:

- Improved the Soldier's ability to control the platform and manage the information it's providing.
- Soldier operational control units for fielded robotic systems are more intuitive and rugged, and provide adequate feedback to the Soldier.
- Designs of future robotics platforms are improved with the inclusion of experimentally tested human-robot interaction principles.



RESEARCH AND TECHNOLOGY FOR THE FUTURE

BATTLEFIELD NEUROSCIENCE

Battlefield neuroscience enables revolutionary advances in Soldier system performance by integrating modern neuroscience, human factors, psychology and engineering, to enhance the understanding of Soldier functions and behaviors in complex operational settings.

What we do: Execute and link neuroscience-based research and implement computational modeling approaches to produce advances in fundamental science and technology, demonstrate and transition technology, and develop research demonstrators for Warfighter experimentation.

Why: A better understanding of how a Soldier's brain, body and sensory systems work together to accomplish tasks in operational and tactical environments can lead to optimal design of human-system interactions for complex battlespace settings.

How:

- Explore neurocognitive performance: neural influences on multi-sensory integration, individual differences in neurophysiology and cognition under real-world stressors, and structural-functional relationship
- Apply advanced computational approaches: multi-dimensional statistical modeling, information extraction algorithms, and cognitive classification techniques
- Deliver neurotechnologies: advanced neural sensor systems, multi-screen display designs, and brain-computer Interaction technologies



Capability:

Methods, approaches, and techniques for enabling the development of neurotechnologies that: fundamentally influence our understanding of the nervous system, integrate knowledge of nervous system function, or integrate measures of nervous system activity to improve Soldier and Soldier-system performance.



OPERATIONAL CAPABILITIES ENABLED BY ARL RESEARCHERS

The technologies in this section represent operational capabilities used in on-going operations by our nation's Warfighters today. The research ARL conducted 2, 5 and even 10 years ago is now providing overwhelming advantages in the lethality and survivability of our Soldiers.

Operational Impact: Gun/Projectile Technologies and Ballistic Modeling



Over the decades, ARL and its predecessor organizations have contributed immeasurably to the development of the best ammunition ever fielded. With its knowledge of propulsion chemistry, physics and aerodynamics, ARL has provided the most lethal small arms projectile the M16 and M4 carbine, the most accurate main battle tank ammunition and has demonstrated up to 75 percent cost savings with indirect fire weapon systems such as the Very Affordable Precision Projectile, or VAPP.



Enhanced Performance Round (EPR)(M855A1)

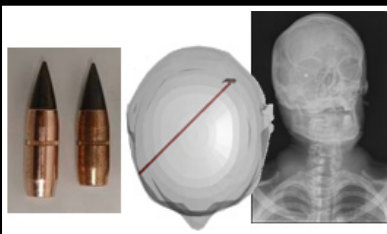
Developed by ARL by applying the science of aerodynamics in large projectiles to those of a small caliber, the Enhanced Performance Round is producing consistent effects against soft targets, increased effectiveness at long ranges, increased defeat of hard targets and reduced muzzle flash. Additionally, the round has a lead-free design and has not increased the overall cartridge weight. The EPR is providing today's Soldier with an affordable and dependable solution bringing the "one shot, one kill" principle closer to reality.

Affordable Precision for Indirect Fire Systems

The Global Positioning System provided first round on target capability for today's artillery systems. ARL's scientists and engineers have revolutionized the affordability of indirect fire systems by providing affordable precision at up to 75 percent cost reduction of current precision indirect fire munitions. This technology enables a paradigm shift from contractor to government owned intellectual property rights in enabling technologies for precision munitions.

Laboratory research leading to the successes listed above involved detailed understanding and determination of fundamental mechanisms including:

- Aerodynamic Interactions
- Propulsion chemistry, modeling and experimentation
- Guidance, navigation and control
- Physics of gun launch



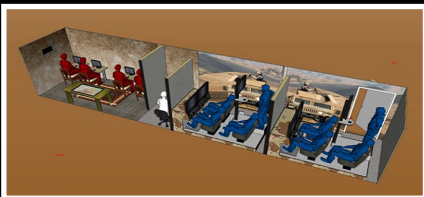
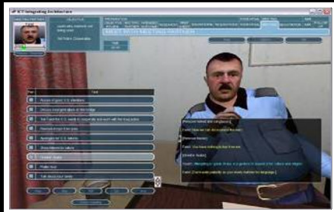
Modeling of Ballistic Vulnerability and Lethality

ARL's analysts help decision makers reduce the vulnerability to our Soldiers. ARL has assessed cockpit floor armor, bar armor on the Husky and mine resistant ambush protected (MRAP) armor upgrades to help program managers improve system design while reducing vulnerabilities.

OPERATIONAL CAPABILITIES ENABLED BY ARL RESEARCHERS

Operational Impact: Training Simulation to the Field

Research provided by the Simulation and Training Technology Center (STTC), now a part of ARL, has led to the fielding of tools for Soldiers' interpersonal skills training that empowers them with a better operational and tactical understanding for social culture interaction and situational awareness. Such understanding is a force multiplier in terms of decision-making capability. Examples of these tools, depicted below are immersive training and game-based simulations, which are fielded to Army training centers.



Tactical Questioning Trainer

This state-of-the-art 3-D interactive environment was developed by ARL to supplement the training of Soldiers in human intelligence gathering. Advanced speech recognition, ease of use and virtual human technology have proven effective and have save DoD \$34 million in software development costs.

BiLAT - BiLateral Negotiation Simulation

BiLateral Negotiation Simulation trains Army leaders in skills necessary to plan and conduct bilateral meetings and negotiations with allied armies, Middle East officials and Tribal/Clan leaders. This interactive immersive simulation has been fielded Army wide.

UrbanSim

Understanding the principles of counterinsurgency and stability operations was the genesis of ARL's development of the first PC, game-based software solution focused on training commanders, staff and Soldiers. UrbanSim is providing commanders with a low-cost training solution.

Mobile Counter – IED Interactive Trainer

ARL is now providing Soldiers with state-of-the-art interactive training software such as the mobile counter-IED interactive trainer that puts the Soldier into the enemy's head to better combat the IED threat.

Laboratory research in the training simulation arena involved capturing human appearance and behavior in virtual or simulated humans for effective interaction.

ARL research is conducted with partners including the Army Research Institute, the University Affiliated Research Centers and the Institute for Creative Technologies (ICT)

- Virtual human basic research
- Medical simulation and training

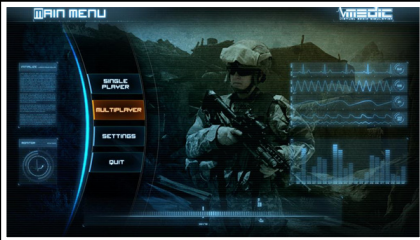
In the area of Virtual Basic Research, capturing human appearance and behavior in virtual human characters and applying laboratory findings led to the development of:

- Demonstrations that virtual human behaviors influence human decisions
- Incremental advances in recognition and generation of speech
- Advanced dialogue authoring methods
- Improved appearance and gesture authoring tools

OPERATIONAL CAPABILITIES ENABLED BY ARL RESEARCHERS

Operational Impact: Training Simulation to the Field

ARL research end results for Soldiers' interpersonal skills training also unburden them, limiting factors such as training areas/facilities and real-life casualties. Examples depicted below are representatives of simulation and virtual training tools, which are fielded to Army training centers.



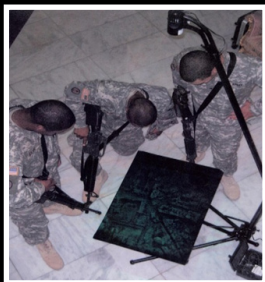
TC3 – Tactical Combat Casualty Care Simulation

ARL has produced the first PC, game-based simulation to train combat medics. This simulation trains medics how to perform the correct procedure at the required time thus saving lives.



CTS – Combat Trauma Simulation (CTS)

CTS is now training Army medical personnel from combat medics to providers in field hospitals, due in large part to the advancements in simulations from ARL researchers. The simulation trains personnel on most tasks related to battlefield injuries.

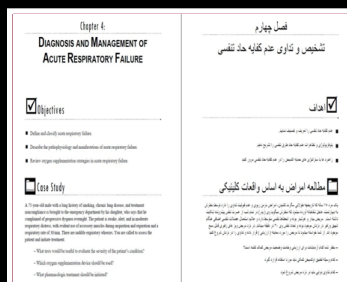


Tactical Digital Holograms

ARL is helping tactical leaders by leading advances in digital holograms that provide 3-D visualizations of current operational theaters. These lightweight, flexible and scratch-resistant images are allowing leaders to rehearse operations and have a better understanding of terrain prior to the Line of Departure.

Operational Impact: Statistical Machine Translation (SMT) tailored to in-theater critical care medical domain

ARL research led to the development of a new SMT engine customized for medical critical care application and production of a high-quality translation of Fundamentals of Critical Care Support (FCCS). This capability renders 5,000 term English-Dari technical glossary, ported to mobile “app” and captures and reuses expert human translation, and repetitive feedback cycles with Afghanistan.



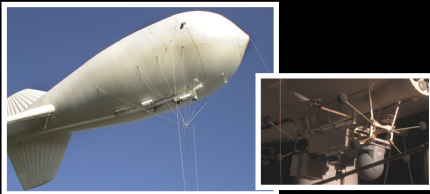
Translation Support

ARL produced the first Dari-English bilingual version of the “Fundamentals of Critical Care.” This machine translation helps medics in Afghanistan and provides accelerated training of local medical personnel for transition of operations.

OPERATIONAL CAPABILITIES ENABLED BY ARL RESEARCHERS

Operational Impact: Persistent Surveillance

Provide Warfighters with the capability to see deeper and wider in the battlefield for a longer period of time through the use of state-of-the-art technology. ARL research in these areas led to the deployment of first infrasonic array to U.S. Forces in Korea; deployment of UTAMS to both Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF); and Aerostat-mounted UTAMS in OEF. ARL's IR detector materials research enables day/night imaging for many Army platforms, including the individual Soldier.



Persistent Threat Detection System and Persistent Ground Surveillance System (PTDS and PGSS)

An aerostat-based Intelligence, Surveillance and Reconnaissance asset developed by ARL is providing enhanced situational awareness through acoustic sensing and optics.

Infrasonic Array

ARL's Infrasonic Array is capable of detecting and locating explosive transients at long distances. Fusing the information provided from the array with other intelligent sources is painting a clearer picture for military leaders.

UTAMS – The Unattended Transient Acoustic MASINT Sensor

The UTAMS is providing Warfighters with a low-cost, small-unit compatible mortar and rocket fire detection system. This 360-degree surveillance system is providing the accurate location of sources beyond the tactical ranges of most threats.

IR Detector Materials

IR detectors and sensors are incorporated over a wide variety of platforms including the individual Soldier, such as the infrared imaging Thermal Weapon Sight. ARL and the Communications and Electronic Research Development and Engineering Center have been the main driving force behind the Army's research and development of infrared technology. Imaging nightvision technology has grown from its early days of primitive image intensifier tubes, which enhance existing light from the moon and stars, to staring megapixel arrays capable of imaging thermal radiation with enough resolution to identify potential targets in complete darkness many kilometers away.

Laboratory research in the persistent surveillance arena involved a deep understanding and exploration of:

- Propagation of infrasound (<20 Hz)
- Acoustic transient detection and localization algorithms
- Infrared (IR) detector materials
- Radar signal processing

OPERATIONAL CAPABILITIES ENABLED BY ARL RESEARCHERS



Constant Hawk

ARL was a partner in the development of Constant Hawk, which is providing operational commanders with a persistent wide area surveillance capability in the battle against IEDs.



Radar Signal Processing

Working with academia, ARL developed a better understanding of ground penetrating radars. These advanced signal processing techniques are providing better detection capabilities for systems such as the Husky.



Current Force Unattended Ground Sensors

ARL's research has led to the networking of ground-based sensors in order to get surveillance data to Soldiers in real time.

Operational Impact: Network Solutions to the Field

ARL research in networks and supporting electronics are producing solutions for Soldiers and have provided the Army with a high degree of network information assurance. Examples of these tools, depicted below, are representative of network and communications tools fielded today.

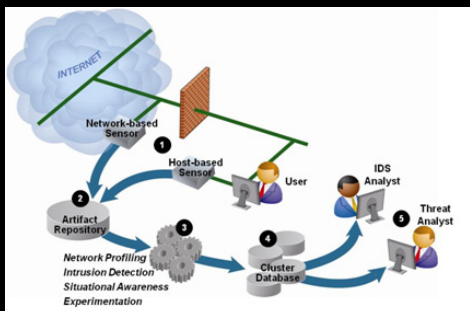


Joint Tactical Radio System (JTRS)

Warfighter feedback to ARL human factors researchers helped drive the final design of the Joint Tactical Radio System. Much of the functional controls were modified based on feedback.

Interrogator

ARL developed an architecture called Interrogator to address protection for network accessible Army/DoD research information - a mission requirement for the ARL Center for Intrusion Monitoring and Protection. Interrogator is comprised of over 20 tools that provide network attack sensing and warning plus a repository of accurate, current network data allowing constant validation and improvement of the toolset, critical to protecting the network-centric Warfighting capability. ARL is providing cutting-edge support to 50 organizations with the deployment of over 230 Interrogator sensors.



OPERATIONAL CAPABILITIES ENABLED BY ARL RESEARCHERS

Operational Impact: Protection Technologies

ARL's work with advanced armor applications, including research into penetration mechanics and innovative defeat mechanisms, has produced unprecedented solutions while reducing weight up to 50 percent and thickness up to 45 percent.



Armor Protection

ARL's research resulted in timely delivery of expeditionary support for various protection enhancing initiatives including MRAP armor weight reduction spiral (MAWRS) program, Abrams passive and reactive armors, the interim fragment kit 6, and the electric protection system on the MRAP.



Electromagnetic Protection System (EPS)

Army vehicles in forward areas face continued threats from rocket propelled grenade (RPG) attacks. Required increases in protection have added considerable weight to systems. To reduce these burdens, ARL researchers have developed, matured and transitioned the EPS technology, which is capable of defeating multiple impacts of unitary RPGs. Working with industry partners, EPS was integrated onto mine resistant ambush protected (MRAP) platforms.

Laboratory research in advancing armored protection technologies was based on ARL determination of the following fundamental mechanisms required to achieve dramatic armor weight reductions

- Penetration mechanics and innovative defeat mechanisms
- Organic material research (advanced composites and polymers)
- Inorganic material research (metals and ceramics)



Underbody Protection

Researchers have made significant contributions into achieving enhanced underbody protection on the tactical fleet of vehicles. Structural reinforcement, underbody kits, seating design and crew protection technology are providing crews with outstanding protection from anti-tank mines and IEDs.



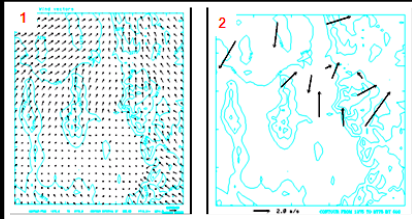
Goldie, Minehound and Beachcomber

These revolutionary hand-held detectors are providing our Soldiers and Marines with a unique capability for the detection of IED components while at the same time reducing false alarms. The devices detect both metal and non-metal IED components and are extremely lightweight and portable.

OPERATIONAL CAPABILITIES ENABLED BY ARL RESEARCHERS

Operational Impact: Atmospheric Decision Aids

The ability to determine weather effects on friendly and threat military systems is enhanced through the fielding of the Integrated Weather Effects Decision Aid (IWEDA) hosted on the fielded Integrated Meteorological System (IMETS) and the new Distributed Common Ground Station-Army (DCGS-A) Weather Services platform. In addition to leading to realization of tools to empower Soldiers, ARL research efforts in atmospheric effects also led to decision aids, which unburden the Soldiers by providing them with the ability to determine weather effects and impacts on friendly and threat military systems.



Weather Running Estimate-Nowcast, WRE-N

ARL developed methods to rapidly create and update local weather forecasts for battlefield applications that include target area analyses and forecasts; radiological, chemical and biological defense; and detailed route planning for manned and unmanned aircraft. The WRE-N is an important tool for providing necessary atmospheric input data for use by atmospheric decision aids.

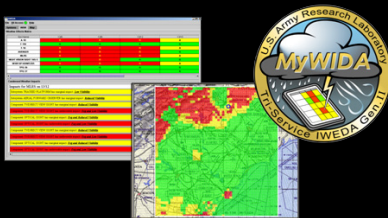


Artillery MET messages (METCM, METB)

ARL meteorologists developed software for use on rugged PDAs to provide Army and Marine gunners with critical meteorological messages, METCM and METB, needed by early entry forces for predicted field artillery fire support.

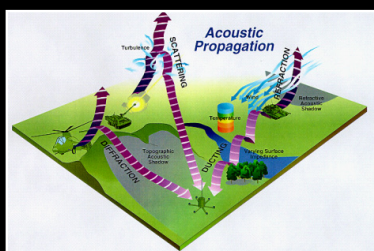
Laboratory research leading to these successes, involving WRE-N and Artillery Meteorological Messages, yielded critical research findings including the following:

- Development of a battlefield weather data objective analysis and interpolation-based technique to rapidly create and update local weather forecasts. Data assimilation techniques developed allow for ingest and use of weather observations from local battlefield weather data sources, thus refining/improving WRE-N performance.
- Realization of capability to compute artillery meteorological computer and ballistic messages (METCM and METB). ARL meteorologists developed algorithms and software hosted on a ruggedized personal digital assistant.



Integrated Weather Effects Decision Aid

ARL's research into the effects of weather on operations is transforming weather data into actionable weather intelligence.



Atmospheric Decision Aids

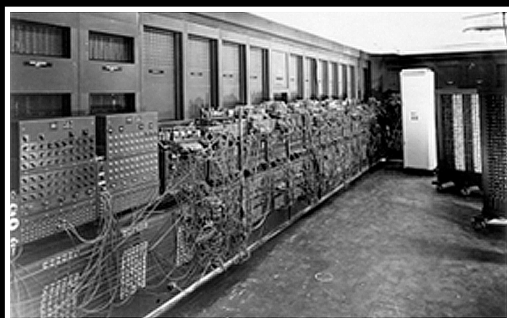
ARL's work with atmospheric decision aids coupled with acoustic signatures from potential targets has increased the probability of detection, identification and tracking of such targets.

The technologies in this section represent only a few of the contributions made by ARL's predecessor organizations or that ARL contributed shortly after it was organized in 1992. But they represent the hard work and dedication of those researchers who paved the way for those serving today.



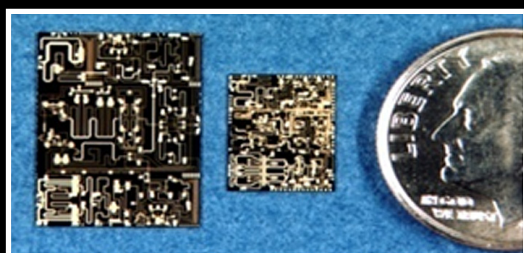
Proximity Fuze

During World War II, a new type of fuze was developed that allowed gunners to detonate a munition during a close encounter with an air target or at some distance above the ground.



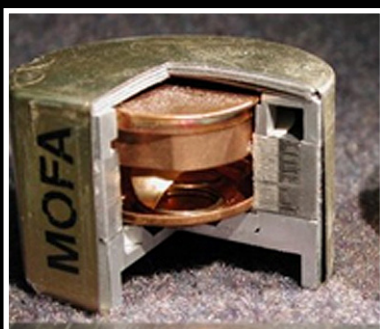
Electronic Numerical Integrator and Computer (ENIAC)

The prototype of today's digital computers, ENIAC, was developed and built in 1946 through a joint venture between the Ballistic Research Laboratory (now part of ARL) and the University of Pennsylvania.



Integrated Printed Circuit Board

ARL was a leader in the development of integrated circuits. They are used in almost all electronic equipment in use today and have revolutionized the world of electronics.



Improved Munition Battery

ARL's research into munitions batteries led to the production of a more reliable fuze battery by incorporating a metal reservoir that provides better protection against rough handling by gunners, and provides depots and ammunition storage points with a capability that reduces storage degradation concerns.



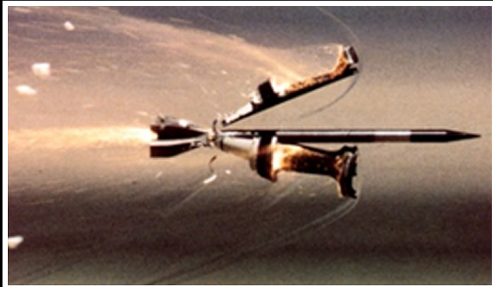
Special Armor for M1 Tank

Equipped with armor developed by ARL, not one hull was penetrated by enemy fire during Operation Desert Storm.



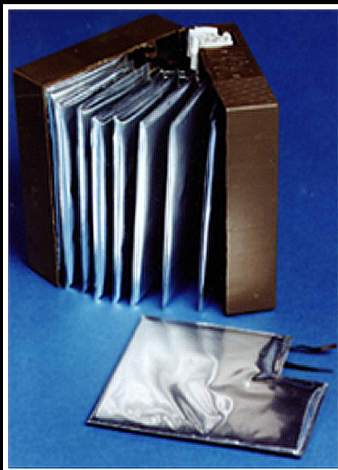
Lithium Primary Batteries

ARL made significant contributions to the development of lithium (Li) batteries. These batteries, still used today, provided superior battery life and power to meet Soldiers' needs.



Family of Abrams KE Tank Ammunition

ARL improvements in advanced composite sabot materials, novel penetrator designs, new propellants, and 3-D computational mechanics analysis greatly increased lethality for the family of ammunition starting with the M829A1 "Silver Bullet" used so successfully in the Gulf War to the currently fielded M829A3.



Photolithography Enabling Integrated Circuits

ARL patented the photolithographic masking technique used to make transistors. This has gone beyond military applications to become an integral part of the electronics industry.



U.S. Army Research Laboratory

